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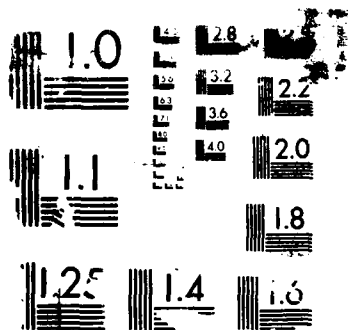
COMBUSTION THEORY AND RELATED QUESTIONS(U) CORNELL UNIV 1/1
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COMBUSTION THEORY AND RELATED QUESTIONS

FINAL REPORT

J.D.BUCKMASTER (FOR G.S.S.LUDFORD)

OCTOBER 1987

U.S.ARMY RESEARCH OFFICE

RESEARCH AGREEMENT NO. DAA G29-85-K-0022

CORNELL UNIVERSITY

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| 19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Asymptotic methods, combustion, detonations, and deflagrations, premixed, and diffusion flames, complex chemistry, strain effects, Stefan problems, explosives, flammability limits, shear bands | | |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Modern asymptotic methods have been applied to a wide range of problems in combustion science and mechanics. Details are contained in the 22 Technical Reports and 5 Ph.D. theses listed. A list of participating scientists is also given. <i>(K. J. ...)</i> | | |

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Objectives and Results

Asymptotic methods were applied to a variety of combustion and related problems, including:

- (i) stability of tube-burner diffusion flames
- (ii) flow-field generated by diffusion flame combustion
- (iii) calculation of the unsteady motion of detonation fronts
- (iv) shock induced explosion of solid explosives
- (v) stability of diffusion flames near extinction
- (vi) effects of stagnation point flow on premixed flames
- (vii) the stability of plane detonation waves
- (viii) flammability limits described by models for complex chemistry
- (ix) shear bands in materials for which the plastic strain rate is sensitive to the thermomechanical state
- (x) structure of detonation waves in granular propellants

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Publications

22 Technical Reports were written, as follows:

181 'The infinite candle and its stability - a paradigm for flickering diffusion flames' by J.Buckmaster and N.Peters. Proceedings of th 22nd Symposium on Combustion, 1987.

182 'On the wind generated by a collapsing diffusion flame' by J.Buckmaster, D.Stewart, A.Ignatiadis, and M.Williams. Combustion Science and Technology, 26,145(1985).

183 'An introduction to combustion theory' by J.Buckmaster, chapter in Mathematics in Combustion, a volume in the SIAM series 'Frontiers in Applied Mathematics'.

184 'The contribution of asymptotics to combustion' by J.Buckmaster, Physica D,20,9(1986)

185 'Reply to comments by Josef Jaroziński' by J.Buckmaster, Combustion and Flame, 59,101(1985).

186 'Numerical aberrations in a Stefan problem from detonation theory' by G.S.S.Ludford and A.A.Oyediran, Proceedings of the Symposium on Numerical Simulation of Combustion Phenomena at Sophia-Antipolis, France.

187 'Low Mach-number combustion' by G.S.S.Ludford, Proceedings of the 1985 AMS-SIAM Symposium on Applied Mathematics (Reacting Flows: Combustion and Chemical Reactors) at Ithaca, NY.

188 'The structure and stability of plane detonation waves for large activation energy' by J.Buckmaster, Proceedings of the 1985 AMS-SIAM Symposium on Applied Mathematics, Ithaca NY.

189 'Plane shock initiation of homogeneous and heterogeneous condensed phase explosives with a sensitivity rate' by D.S.Stewart, Proceedings of the 1985 AMS-SIAM Symposium on Applied Mathematics, Ithaca NY.

190 'Numerical aberrations in a Stefan problem from detonation theory' by G.S.S.Ludford and A.A.Oyediran, Transactions of the 3rd Army Conference on Applied Mathematics and Computing (at Atlanta, Georgia).

191 'Further investigations of the stability of diffusion flames near extinction' by Y.S.Choi and G.S.S.Ludford, Transactions of the 3rd Army Conference on Applied Mathematics and Computing (at Atlant, Georgia).

192 'Complex kinetics in flame theory' by G.S.S.Ludford and R.Tam, Transactions of the 3rd Army Conference on Applied Mathematics and Computing.

193 'Displacement effect of a flame in a stagnation-point flow' by E.Eteng, G.S.S.Ludford, and M.Matalon, to be published in Physics of Fluids.

194 'The effect of structure on the stability of detonation. I. Role of the induction zone' by J.Buckmaster and G.S.S.Ludford, Proceedings of the 22nd Symposium on Combustion, 1986.

195 'Plane shock initiation of homogeneous and heterogeneous condensed phase explosives with a sensitivity rate' by D.S.Stewart, to appear in Combustion Science and Technology.

196 'On the stability of Linan's premixed flame regime revisited' by D.S.Stewart and J.Buckmaster, to appear in SIAM Journal of Applied Mathematics.

197 'The lifting of turbulent diffusion flames and the noise they make' by J.Buckmaster and N.Peters, article in Lectures in Applied Mathematics, vol.24, p.489(1986).

198 'Stability of a detonation wave' by F.S.Hall and G.S.S.Ludford, to appear in Physica D.

199 'Kinetic extinction: a three-step model' by R.Y.Tam and G.S.S.Ludford, submitted to Combustion and Flame.

200 'The lean flammability limit: a four-step model' by R.Y.Tam and G.S.S.Ludford, submitted to Combustion and Flame.

201 'Structure of two phase steady detonation and composition waves' by J.Powers, D.Stewart, and H.Krier, submitted for publication.

202 'Shear bands and localization theory in nonlinear solids' by D.Stewart, submitted for publication.

Ph.D Theses

5 were completed, as follows:

| | |
|------------|---|
| R.Y.Tam | 'Complex Kinetics in Combustion Modeling', August 1986 |
| Y.S.Choi | 'Chambered diffusion flame with general Lewis number', August 1986 |
| F.Hall | 'Stability of a detonation wave', January 1987 |
| A.Oyediran | 'Unsteady detonations', June 1985 |
| E.Eteng | 'Density-stratified stagnation-point flow' June 1986 |

In addition, M.Williams completed a Master's thesis based on
Technical Report 182.

Account of research of Charles Roten, Visiting Assistant
Professor, July 1986 - August 1987

1. preprint:

"Modelling and Analysis of H_2-O_2 combustion between 1100 and
1600 degrees", C.D. Roten and P.C. Fife.

M.S.I. Technical Report - same title

presented at

the Conference on Mathematical Modelling and Combustion,
Ecole Centrale de Lyon, April 27-30, 1987.

Abstract:

A detailed nonnumerical analysis of hydrogen-oxygen
combustion at 1 atmosphere between 1100° and 1600° is
presented. MACSYMA is used to implement an algorithm which
constructs candidates for the allocation vector by a
comparison of the reaction rate functions which accounts for
competition, autocatalysis, and partial equilibrium of
reactions. A method for examining how these allocations
change with temperature is also presented. A "plateau"
temperature toward which the reaction temperature tends is
found for the case where the initial mixture is
hydrogen-rich. In the hydrogen-lean case successive
bifurcations of strongly and weakly recombinant chemistries
leads to a set of upper and lower bounds for the plateau
temperature. The global chemical reactions which dominate
the stoichiometry are found for both cases, and the heat
release in the reaction zone is determined as a function of
the relative participation of the different global
reactions.

2. preprint:

"A class of singular boundary value problems which possess nonsmooth bifurcation curves", C.D. Roten and R.W. Kolkka.

Abstract:

The problem of finding limit points in bifurcation diagrams of nonlinear boundary value O.D.E.'s is examined. Bifurcation curves for singular and nonsingular boundary value O.D.E.'s are constructed by Poincare-Linstedt expansions, and numerically. The local expansions are found to agree with the numerical results only for the nonsingular problems and for points on the singular problems' bifurcation diagrams between the initial bifurcation point and the O.D.E.'s singular solution. The numerical results at the singular points on the bifurcation curves are shown to be qualitatively correct. An asymptotic method for location of the singular solutions is developed and justified. The local expansions are shown to predict their own failure in the singular problems.

Participating Scientists

Y.S.Choi, R.Y.Tam, F.Hall, E.Eteng were supported for various periods as Research Assistants.

Professor J.D.Buckmaster of the University of Illinois, Urbana, was a Visiting Professor for various periods. Professor D.S.Stewart of the University of Illinois, Urbana, was a visiting Assistant Professor. Professor C.Roten of Mississippi State University was a Visiting Assistant Professor. Dr.C.Laine of the Ecole Centrale de Lyon was a Visiting Scientist.

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